Chapter 1:
Introduction to Computers, the Internet and the Web

Java™ How to Program, 8/e
Computer System

- **Hardware** (physical parts, e.g., keyboard, mouse, hard disk, memory, processing units)

- **Software** (computer programs, libraries, non-executable data, e.g., documentation)

- Hardware is directed by software to execute commands or instructions. A combination of hardware and software forms a usable computer system.
The von Neumann Architecture

- A design model for a stored-program digital computer

John von Neumann (1903-1957)
Hungarian-American mathematician, physicist
Following the von Neumann architecture, modern computers consist of the following logical units:

- Input unit
- Output unit
- Memory unit (内存，主存)
- Arithmetic and logic unit (ALU, 算术逻辑单元)
- Central processing unit (CPU, 中央处理器)
- Secondary storage unit (辅助存储单元，二级存储器)
Input Unit

- The “receiving” section of a computer
- Obtains information (data and programs…) for other units to process.
Output Unit

- The “shipping” section of a computer
- Takes the information that the computer has processed and makes it available for use outside the computer.
Memory Unit

- Rapid-access, relatively low-capacity “warehouse” section
- Retains information entered through the input unit, making it immediately available for processing when needed.
- Retains processed information until it is placed on output devices.
- Information in the memory unit is volatile (易失) and will be lost when the computer’s power is turned off.
- Also known as main memory, primary memory, memory, or RAM (Random Access Memory).

http://people.scs.carleton.ca/~armyunis/notes/ram.htm
Arithmetic and Logic Unit (ALU)

- “Manufacturing” section that performs calculations, such as addition, subtraction, multiplication and division.

- Contains the mechanisms that allow the computer to make decisions, e.g., comparing two items from the memory to determine whether they are equal.

- In today’s computer systems, the ALU is usually implemented as part of a CPU.
Central Processing Unit (CPU)

- “Administrative” section that coordinates the operations of the other units (the brain/heart of a computer).
  - Tells the input unit when information should be read into the memory unit
  - Tells the ALU when information in the memory unit should be used in calculations
  - Tells the output unit when to send information from the memory unit to output devices
Central Processing Unit (CPU)

- Many of today’s computers have multiple CPUs (can perform operations simultaneously). They are called **multiprocessors**.

- A **multicore processor** implements multiprocessing on a single integrated circuit chip (e.g., dual-core, quad-core, octa-core).

How many cores in your phone?
Secondary Storage Unit

- Long-term, high-capacity “warehousing” section
- Programs or data **not actively being used** by the other units normally are placed on the secondary storage units (e.g., hard drive)
- Information on secondary storage devices is **persistent** and will be preserved even when the computer is turned off
- Storage devices are typically much cheaper than main memory.
Are They Computers

- What is the input unit?
- What is the output unit?
- Do they have CPU, RAM and disk?
What is a computer program?

- Human work model

- Computer work model

- A computer program is a set of machine-readable instructions that tells a computer how to perform a specific task.
What is a (programming) language?

A sequence of instructions

\[\text{An algorithm (算法)} \quad \text{A program (in human language)} \quad \text{A program (in computer language)}\]

- Programs are written in programming languages
- There are many programming languages
  - Low-level (低级语言), understandable by a computer
  - High-level (高级语言), needs a translator!
Can you understand this?
main:

!#PROLOGUE# 0
save %sp,−128,%sp
!#PROLOGUE# 1
mov 1,%o0
st %o0,[%fp−20]
mov 2,%o0
st %o0,[%fp−24]
ld [%fp−20],%o0
ld [%fp−24],%o1
add %o0,%o1,%o0
st %o0,[%fp−28]
mov 0,%i0
nop

How about this?
int valueOfZ() {
    int x, y, z;
    x = 1;
    y = 2;
    z = x + y;
    return z;
}
Levels of programming languages

- Machine (binary) language is unintelligible (bits)

0000100100101110011001100110100101101100011001010000100100100010011011011000110
010101100110111010001110101011100100110010010110010001001011100110011001000100
0001010011001110110001101100011011000110011010011111011100011101101111011011010110
000011010010110110001100101011001000101110011101000111010101110011001010010000110
110010101100011011101000110010110111101101100000100100100010011011001100110010110
1001110010101111000011101000100010010000101000000100100110011001100101101100001010110
11010010110011011011000100000011010000010100001001001101100110011001101011101011100
1000110111101100011011011100110010001011011000110100101101110011000110010001000110
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1110100011010010110111101101101011011000110000010100000100100101110100011100001110011
Levels of programming languages

- **Assembly language (汇编语言)** is low level
  - **Mnemonic names (助记符)** for machine operations
  - Explicit manipulation of memory addresses and contents
  - **Machine-dependent**

```assembly
main:
!#PROLOGUE# 0
save %sp, -128,%sp
!#PROLOGUE# 1
mov 1, %o0
st %o0, [%fp - 20]
mov 2, %o0
st %o0, [%fp - 24]
ld [%fp - 20], %o0
ld [%fp - 24], %o1
add %o0, %o1, %o0
st %o0, [%fp - 28]
mov 0, %i0
nop
```
Levels of programming languages

- High-level language
  - Readable: instructions are easy to remember (faster coding)
  - Less error-prone
  - No mention of memory locations
  - Machine-independent = portable

```c
int valueofz() {
    int x, y, z;
    x = 1;
    y = 2;
    z = x + y;
    return z;
}
```
Genealogy of programming languages

[Diagram showing the evolution of programming languages from Fortran I to Java, with Java highlighted.]
Compilation: from source to executables

- A compiler (编译器) translates source programs written in high-level languages into machine codes that can run directly on the target computer.
An **interpreter** (解释器) directly executes the statements from source code, without requiring the programs to have been compiled into machine codes.
# Compiler vs. Interpreter

<table>
<thead>
<tr>
<th>Interpreter</th>
<th>Compiler</th>
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<tr>
<td>Interprets and executes one statement at a time.</td>
<td>Scans the entire program and translates it as a whole into machine codes.</td>
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<td>Takes less time to analyze the source code but the overall execution is usually slower.</td>
<td>Takes more time to analyze the source code but the overall execution is typically faster.</td>
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<td>Continues executing a program until the first error is met, in which case it stops.</td>
<td>Programs are executable only after they are successfully compiled.</td>
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<td>Programming languages like Python, Ruby use interpreters.</td>
<td>Programming languages like C, C++ use compilers.</td>
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What is software?

A set of programs (also including libraries and non-executable data, e.g., documentation)

- **Application software (应用软件):** Programs designed for specific tasks. They are typically easy to use.
  - MS Word, PowerPoint, Chrome, Photoshop, WeChat etc.

- **System software (系统软件):** Programs that support the execution and development of other programs.
  - Operating systems (e.g., Windows, Mac OS X, Linux for desktops, and iOS & Android for mobile devices)
  - Translation systems (e.g., compilers, assemblers)
What is the Internet (因特网)?

- A global network of computers. It dates back to the research commissioned by the United States Federal Government to build robust, fault-tolerant communication via computer networks (1960s).

- The linking of commercial networks and enterprises in the early 1990s marked the beginning of the transition to the modern Internet, and generated rapid growth as institutional, personal, and mobile computers were connected to the network.

- By the late 2000s, its services and technologies had been incorporated into virtually every aspect of human lives.

https://en.wikipedia.org/wiki/Internet
What is the World Wide Web?

- The World Wide Web (万维网), or simply the Web, is a way of accessing information over the medium of the Internet. It is an information-sharing model that is built on top of the Internet.

- The Web uses the HTTP protocol to transmit data. Web services, which use HTTP to allow applications to communicate in order to exchange business logic, use the Web to share information.

- Users can use browsers, such as Chrome to access Web documents called web pages that are linked to each other via hyperlinks. Web documents contain graphics, sounds, and video.
Web 2.0
Web 2.0

- Web usage exploded in the **mid-to-late 1990s**. During this period, many Internet-based companies were founded, many of which failed (**doc-com economic crisis**).

- Resurgence began in 2004 with Web 2.0, which refers to the websites that emphasize **user-generated content, usability, and interoperability** for end users (for example, **微博**).
Web 2.0

- A Web 2.0 website may allow users to interact and collaborate with each other in a social media dialogue as content creators in a virtual community (user-centric, sharing, social, interactive, dynamic)

- In contrast, on the first-generation websites (there is no such a term Web 1.0), people were limited to the passive viewing of content.

- Signature companies in the Web 2.0 era: Google, Facebook, YouTube, Tencent
We learn Java, why?

- An object-oriented computer programming language – today’s key methodology
- The most widely used computer programming language – billions of devices run Java programs
- Preferred for Internet-based applications and devices over a network
A brief history of Java

- Microprocessors have a profound impact in intelligent consumer-electronic devices. Personal computers and hand-held devices become possible.

- In 1991, Sun Microsystems (acquired by Oracle in 2009) funded an internal research project, aiming to achieve the goal of "write once, run anywhere". This resulted in a C++-based language named Java.

The father of Java: James Gosling
A brief history of Java

- In 1993, Sun saw the potential of using Java to add **dynamic content** to web pages. Java's connection to the Internet began.

- In 1995, Java was officially released and the Netscape browser (网景浏览器) started to support Java.
Java Editions

- **Java Standard Edition (Java SE)**
  - Java SE 11 (long term support) was released in Sept. 2018

- **Java Enterprise Edition (Java EE)**
  - For large-scale, distributed networking and web-based applications

- **Java Micro Edition (Java ME)**
  - For small, memory-constrained devices, e.g., micro controllers, sensors, TV boxes etc.
Java programming steps

- **Edit** (write the program and store it in the disk `.java`)
- **Compile** (create bytecodes and store them in a file `.class`)
- **Load** (read `.class` files and put those bytecodes in memory)
- **Verify** (confirm the bytecodes are valid and secure)
- **Execute** (run the program in Java Virtual Machine or JVM)
Java is both compiled and interpreted

Source code
Hello.java

Compiler
javac Hello.java

Byte code
Hello.class

Interpreter
java Hello

Output
Java is platform independent

```
edit Hello.java

javac Hello.java

java Hello.class

“Hello World!”
```
Integrated Development Environment (IDE)

- Combine all the capabilities that a programmer would want while developing software (Eclipse, IntelliJ IDEA, BlueJ, etc.)
  - We will use IDEA in this course ([https://www.jetbrains.com/idea/](https://www.jetbrains.com/idea/))
  - BlueJ is good for beginners ([https://www.bluej.org/](https://www.bluej.org/))

- Before you begin programming, install JDK (Java SE Software Development Kit) and set the PATH Environment Variable properly (attend the first lab to learn this)
  - [http://www.oracle.com/technetwork/java/javase/downloads](http://www.oracle.com/technetwork/java/javase/downloads)
The **Java Development Kit (JDK)** is a software development environment for developing Java programs. It includes:

- A Java Runtime Environment (JRE, 运行环境)
- An interpreter/loader (`java`)
- A compiler (`javac`),
- An archiver (`jar`),
- A documentation generator (`javadoc`)
- Other tools needed in Java development.

**In short, JDK = JRE + Development tools**
The **Java Runtime Environment (JRE)** provides the minimum requirements for executing a Java application. It consists of the Java Virtual Machine (JVM), core classes, and supporting files.

A **Java Virtual Machine (JVM)** is an abstract computing machine that enables a computer to run a Java program.

In short, **JRE = JVM + Library classes**
What is debugging?

- The process of tracking down and **correcting bugs (errors)** in your programs
  
  - **Syntax Errors** (语法错误): Syntax refers to the structure of your program and the rules about that structure (e.g., missing a semicolon at the end of a statement)
  
  - **Runtime Errors** (运行时错误, 异常): Runtime errors or exceptions occur when the interpreter is running the byte code and something goes wrong, e.g., an infinite recursion (无限递归) causes a StackOverflowException
  
  - **Logic Errors** (逻辑错误): The semantics or meaning of your program are wrong (e.g., it yields an unexpected result)